Part I
Getting Started

Chapter 1
Understanding Risk and Building Partnerships

Contents

Understanding Risk and Building Partnerships

This chapter will help you:

- *Understand the basic principles of risk assessment and the science behind it.*
- *Build partnerships between a company that generates and manages waste, the community within which the company lives and works, and the state agency that regulates the company in order to build trust and credibility among all parties.*

Residents located near waste management units want to understand the management activities taking place in their neighborhoods. They want to know that waste is being managed safely, without danger to public health or the environment. This requires an understanding of the basic principles of risk assessment and the science behind it. Opportunities for dialogue between facilities, states, tribes, and concerned citizens, including a discussion of risk factors, should take place before decisions are made. Remember, successful partnerships are an ongoing activity.

I. Understanding Risk Assessment

Environmental risk communication skills are critical to successful partnerships between companies, state regulators, the public, and other stakeholders. As more environmental management decisions are made on the basis of risk, it is increasingly important for all interested parties to understand the science behind risk assessment. Encouraging public participation in environmental decision-making means ensuring that all interested parties understand the basic principles of risk assessment and can converse equally on the development of assumptions that underlie the analysis.

A. Introduction to Risk Assessment

This Guide provides simple-to-use risk assessment tools that can assist in determining the appropriate waste management practices for surface impoundments, landfills, waste piles, and land application units. The tools estimate potential human health impacts from a waste management unit by modeling two possible exposure pathways: releases through volatile air emissions and contaminant migration into ground water. Although using the tools is simple, it is still essential to understand the basic concepts of risk assessment to be able to interpret the results and understand the nature of any uncertainties associated with the analysis. This section provides a general overview of the scientific principles underlying the methods for quantifying cancer and

> This chapter will help address the following questions.
>
> - What is risk and how is it assessed?
> - What are the benefits of building partnerships?
> - What methods have been successful in building partnerships?
> - What is involved in preparing a stakeholder meeting?

noncancer risk. Ultimately, understanding the scientific principles will lead to more effective use of the provided tools.

B. Types of Risk

Risk is a concept used to describe situations or circumstances that pose a hazard to people or things they value. People encounter a myriad of risks during common everyday activities, such as driving a car, investing money, and undergoing certain medical procedures. By definition, risk is comprised of two components: the probability that an adverse event will occur and the magnitude of the consequences of that adverse event. In capturing these two components, risk is typically stated in terms of the probability (e.g., one chance in one million) of a specific harmful "endpoint" (e.g., accident, fatality, cancer).

In the context of environmental management and this section in the Guide, risk is defined as the probability or likelihood that public health might be unacceptably impacted from exposure to chemicals contained in waste management units. The risk endpoints resulting from the exposure are typically grouped into two major consequence categories: cancer risk and noncancer risk.

The cancer risk category captures risks associated with exposure to chemicals that might initiate cancer. To determine a cancer risk, one must calculate the probability of an individual developing any type of cancer during his or her lifetime from exposure to carcinogenic hazards. Cancer risk is generally expressed in scientific notation; in this notation, the chance of 1 person in 1,000,000 of developing cancer would be expressed as 1×10^{-6} or 1E-6.

The noncancer risk category is essentially a catch-all category for the remaining health effects resulting from chemical exposure. Noncancer risk encompasses a diverse set of effects or endpoints, such as weight loss, enzyme changes, reproductive and developmental abnormalities, and respiratory reactions. Noncancer risk is generally assessed by comparing the exposure or average intake of a chemical with a corresponding reference (a health benchmark), thereby creating a ratio. The ratio so generated is referred to as the hazard quotient (HQ). An HQ that is greater than 1 indicates that the exposure level is above the protective level of the health benchmark, whereas, an HQ less than 1 indicates that the exposure is below the protective level established by the health benchmark.

It is important to understand that exposure to a chemical does not necessarily result in an adverse health effect. A chemical's ability to initiate a harmful health effect depends on the toxicity of the chemical as well as the route (e.g., ingestion, inhalation) and dose (the amount that a human intakes) of the exposure. Health benchmark values are used to quantify a chemical's possible toxicity and ability to induce a health effect, and are derived from toxicity data. They represent a "dose-response"[1] estimate that relates the likelihood and severity of adverse health effects to exposure and dose. The health benchmark is used in combination with an individual's exposure level to determine if there is a risk. Because individual chemicals generate different health effects at different doses, benchmarks are chemical specific; additionally, since health effects are related to the route of exposure and the timing of the exposure, health benchmarks are specific to the route and the duration (acute, subchronic, or chronic) of the exposure. The definitions of acute, subchronic, and chronic exposures vary, but acute typically implies an exposure of less than one day, subchronic generally indicates an exposure of a few weeks to a few months, and chronic exposure can span periods of several months to several years.

[1] Dose-response is the correlative relationship between the dose of a chemical received by a subject and the degree of response to that exposure.

The health benchmark for carcinogens is called the cancer slope factor. A cancer slope factor (CSF) is defined as the upper-bound[2] estimate of the probability of a response per unit intake of a chemical over a lifetime and is expressed in units of (mg/kg-d). The slope factor is used to estimate an upper-bound probability of an individual developing cancer as a result of a lifetime of exposure to a particular concentration of a carcinogen.

A reference dose (RfD) for oral exposure and reference concentration (RfC) for inhalation exposure are used to evaluate noncancer effects. The RfD and RfC are estimates of daily exposure levels to individuals (including sensitive populations) that are likely to be without an appreciable risk of deleterious effects during a lifetime and are expressed in units of mg/kg-d (RfD) or mg/m^3 (RfC).

Most health benchmarks reflect some degree of uncertainty because of the lack of precise toxicological information on the people who might be most sensitive (e.g., infants, elderly, nutritionally or immunologically compromised) to the effects of hazardous substances. There is additional uncertainty because most benchmarks must be based on studies performed on animals, as relevant human studies are lacking. From time-to-time benchmark values are revised to reflect new toxicology data on a chemical. In addition, because many states have developed their own toxicology benchmarks, both the groundwater and air tools in this Guide enable a user to input alternative benchmarks to those that are provided.

There are several sources for obtaining health benchmarks, some of which are summarized in the text box on the following page. Most of these sources have toxicological profiles and fact sheets on specific chemicals that are written in a general manner and summarize the potential risks of a chemical and how it is currently regulated. One good Internet source is the Agency for Toxic Substances and Disease Registry (ATSDR) **<www.atsdr.cdc.gov>**. ATSDR provides fact sheets for many chemicals. These fact sheets are easy to understand and provide general information regarding the chemical in question. An example for cadmium is provided in the appendix at the end of this chapter. Additional Internet sites are also available such as: the Integrated Risk Information System (IRIS); EPA's Office of Air Quality Planning and Standards Hazardous Air Pollutants Fact Sheets; EPA's Office of Ground Water and Drinking Water Contaminant Fact Sheets; New Jersey's Department of Health, Right to Know Program's Hazardous Substance Fact Sheets; Environmental Defense's Chemical Scorecard; EPA's Office of Pollution Prevention and Toxics (OPPT) Chemical Fact Sheets, American Chemistry Council (ACC), and several others. Visit the Envirofacts Warehouse Chemical References Complete Index at **<www.epa.gov/enviro/html/emci/chemref/complete_index.html>** for links to these Web sites.

Example of Health Benchmarks for Acrylonitrile

Chronic:
- inhalation CSF: 0.24 (mg/kg-d)
- oral CSF: 0.54 (mg/kg-d)
- RfC: 0.002 mg/m^3
- RfD: 0.001 mg/kg-d

Subchronic:
- RfC: 0.02 mg/m^3

Acute:
- ATSDR MRL: 0.22 mg/m^3

C. Assessing Risk

Sound risk assessment involves the use of an organized process of evaluating scientific data. A risk assessment ultimately serves as

[2] Upper-bound is a number that is greater than or equal to any number in a set.

Sources for Health Benchmarks

Integrated Risk Information System (IRIS) The Integrated Risk Information System (IRIS) is the Agency's official repository of Agency-wide, consensus, chronic human health risk information. IRIS contains Agency consensus scientific positions on potential adverse human health effects that might result from chronic (or lifetime) exposure to environmental contaminants. IRIS information includes the reference dose for noncancer health effects resulting from oral exposure, the reference concentration for noncancer health effects resulting from inhalation exposure, and the carcinogen assessment for both oral and inhalation exposure. IRIS can be accessed at **<www.epa.gov/iris>**.

Health Effects Assessment Summary Tables (HEAST) HEAST is a comprehensive listing compiled by EPA consisting of risk assessment information relative to oral and inhalation routes for chemicals. HEAST benchmarks are considered secondary to those contained in IRIS. Although the entries in HEAST have undergone review and have the concurrence of individual Agency Program Offices, they have either not been reviewed as extensively as those in IRIS or they do not have as complete a data set as is required for a chemical to be listed in IRIS. HEAST can be ordered from NTIS by calling 1-800-553-IRIS or accessing their Website at **<www.ntis.gov>**.

Agency for Toxic Substances and Disease Registry (ATSDR) The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), requires that the Agency for Toxic Substances and Disease Registry (ATSDR) develop jointly with the EPA, in order of priority, a list of hazardous substances most commonly found at facilities on the CERCLA National Priorities List; prepare toxicological profiles for each substance included on the priority list of hazardous substances; ascertain significant human exposure levels (SHELs) for hazardous substances in the environment, and the associated acute, subchronic, and chronic health effects; and assure the initiation of a research program to fill identified data needs associated with the substances. The ATSDR Minimal Risk Levels (MRLs) were developed as an initial response to the mandate. MRLs are based on noncancer health effects only and are not based on a consideration of cancer effects. MRLs are derived for acute (1-14 days), intermediate (15-364 days), and chronic (365 days and longer) exposure durations, for the oral and inhalation routes of exposure. ATSDR's toxicological profiles can be accessed at **<www.atsdr.cdc.gov/toxfaq.html>**.

guidance for making management decisions by providing one of the inputs to the decision making process. Risk assessment furnishes beneficial information for a variety of situations, such as determining the appropriate pollution control systems for an industrial site, predicting the appropriateness of different waste management options or alternative waste management unit configurations, or identifying exposures that might require additional attention.

The risk assessment process involves data collection activities, such as identifying and characterizing the source of the environmental pollutant, determining the transport of the pollutant once it is released into the environment, determining the pathways of human exposure, and identifying the extent of exposure for individuals or populations at risk.

Performing a risk assessment is complex and requires knowledge in a number of scientific disciplines. Experts in several areas, such as toxicology, geochemistry, environmental engineering, and meteorology, can be involved in performing a risk assessment. For the purpose of this section, and for brevity, the basic components important to consider when assessing risk are summarized in three main categories listed below. A more extensive discussion of these components can be found in the references listed at the end of this section. The three main categories are:

1. **Hazard Identification:** identifying and characterizing the source of the potential risk (e.g., chemicals managed in a waste management unit).
2. **Exposure Assessment:** determining the exposure pathways and exposure routes from the source to an individual.
3. **Risk Characterization:** integrating the results of the exposure assessment with information on who is potentially at risk (e.g., location of the person, body weights) and chemical toxicity information.

1. Hazard Identification

For the purpose of the Guide, the source of the potential risk has already been identified: waste management units. However, there must be a release of chemicals from a waste management unit for there to be exposure and risk. Chemicals can be released from waste management units by a variety of processes, including volatilization (where chemicals in vapor phase are released to the air), leaching to ground water (where chemicals travel through the ground to a groundwater aquifer), particulate emission (where chemicals attached to particulate matter are released in the air when the particulate matter becomes airborne), and runoff and erosion (where chemicals in soil water or attached to soil particles move to the surrounding area).

To consider these releases in a risk assessment, information characterizing the waste management unit is needed. Critical parameters include the size of the unit and its location. For example, larger units have the potential to produce larger releases. Units located close to the water table might produce greater releases to ground water than units located further from the water table. Units located in a hot, dry, windy climate can produce greater volatile releases than units in a cool, wet, non-windy climate.

2. Exposure Assessment: Pathways, Routes, and Estimation

Individuals and populations can come into contact with environmental pollutants by a variety of exposure mechanisms and processes. The mere presence of a hazard, such as toxic chemicals in a waste management unit, does not denote the existence of a risk. Exposure is the bridge between what is considered a hazard and what actually presents a risk. Assessing exposure involves evaluating the potential or actual pathways for and extent of human contact with toxic chemicals. The magnitude, frequency, duration, and route of exposure to a substance must be considered when collecting all of the data necessary to construct a complete exposure assessment.

The steps for performing an exposure assessment include identifying the potentially exposed population (receptors); pathways of exposure; environmental media that transport the contaminant; contaminant concentration at a receptor point; and receptor's exposure time, frequency, and duration. In a deterministic exposure assessment, single values are assigned to each exposure variable. For example, the length of time a person lives in the same residence adjacent to the facility might be assumed to be 30 years. Alternatively, in a probabilistic analysis, single values can be replaced with probability distribution functions that represent the range in real-world variability, as well as uncertainty. Using the time in residence example, it might be found that 10 percent of the people adjacent to the facility live in their home for less than three years, 50 percent less than six years, 90 percent less than 20 years, and 99 percent less than 27 years.

A probabilistic risk assessment is performed by running the equations that describe each distribution in a program in conjunction with a Monte Carlo program. The Monte Carlo program randomly selects a value from the designated distribution and mathematically treats it with numbers randomly selected from distributions for other parameters. This process is repeated a number of times (e.g., 10,000 times) to generate a distribution of theoretical values. The person assessing risk then uses his or her judgement to select the risk value (e.g., 50th or 90th percentile).

The output of the exposure assessment is a numerical estimate of exposure and intake of a chemical by an individual. The intake information is then used in concert with chemical-specific health benchmarks to quantify risks to human health.

Before gathering these data, it is important to understand what information is necessary for conducting an adequate exposure assessment and what type of work might be required. Exposures are commonly determined by using mathematical models of chemical fate and transport to determine chemical movement in the environment in conjunction with models of human activity patterns. The information required for performing the exposure assessment includes site-specific data such as soil type, meteorological conditions, ground-water pH, and location of the nearest receptor. Information must be gathered for the two components of exposure assessment: exposure pathways/routes and exposure quantification/estimation.

a. *Exposure Pathways/Routes*

An exposure pathway is the course the chemical takes from its source to the individual or population it reaches. Chemicals cycle in the environment by crossing through the different types of media which are considered exposure pathways: air, soil, ground water, surface water, and biota (Figure 1). As a result of this movement, a chemical can be present in various environmental media, and human exposure often results from multiple sources. The relative importance of an exposure pathway depends on the concentration of a chemical in the relevant medium and the rate of intake by the exposed individual. In a comprehensive risk assessment, the risk assessor identifies all possible site-specific pathways through which a chemical could move and reach a receptor. The Guide provides tools to model the transport and movement of chemicals through two environmental pathways: air and ground water.

The transport of a chemical in the environment is facilitated by natural forces: wind and water are the primary physical processes for distributing contaminants. For example, atmospheric transport is frequently caused by ambient wind. The direction and speed of the wind determine where a chemical can be found. Similarly, chemicals found in surface water and ground water are carried by water currents or sediments suspended in the water.

The chemistry of the contaminants and of the surrounding environment, often referred to as the "system," also plays a significant role in determining the ultimate distribution of pollutants in the various types of media. Physical-chemical processes, including dissolution/precipitation, volatilization, photolytic and hydrolytic degradation, sorption, and complexation, can influence the distribution of chemicals among the different environmental media and the transformation from one chemical form to another[3]. An important component of creating a conceptual model for performing a risk assessment is the identification of the relevant processes that occur in a system. These complex processes depend on the conditions at the site and specific chemical properties.

[3] Kolluru, Rao (1996).

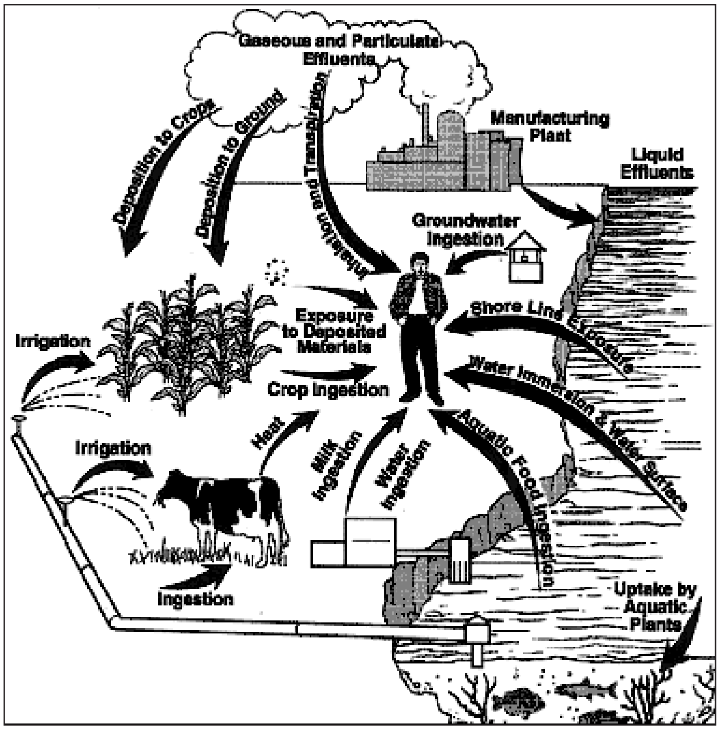

Figure 1. Multiple Exposure Pathways/Routes *(National Research Council, "Frontiers in Assesssing Human Exposure," 1991)*

Whereas the exposure pathway dictates the means by which a contaminant can reach an individual, the exposure route is the way in which that chemical comes in contact with the body. To generate a health effect, the chemical must come in contact with the body. In environmental risk assessment, three exposure routes are generally considered: ingestion, inhalation, and dermal absorption. As stated earlier, the toxicity of a chemical is specific to the dose received and its means of entry into the body. For example, a chemical that is inhaled might prove to be toxic and result in a harmful health effect, whereas the same chemical might cause no reaction if ingested, or vice-versa. This phenomenon is due to the differences in physiological response once a chemical enters the body. A chemical that is inhaled reaches the lungs and enters the blood system. A chemical that is ingested might be metabolized into a different chemical that might result in a health effect or into another chemical that is soluble and can be excreted.

Some contaminants can also be absorbed by the skin. The skin is not very permeable and usually provides a sufficient barrier against most chemicals. Some chemicals, however, can pass through the skin in sufficient quantities to induce severe health effects. An example is carbon tetrachloride, which is readily absorbed through the skin and at certain doses can cause severe liver damage. The dermal route is typically considered in worker scenarios in which the worker is actually performing activities that involve skin contact with the chemical of concern. The tools provided in the Guide do not address the dermal route of exposure.

b. Exposure Quantification/Estimation

Once appropriate fate-and-transport modeling has been performed for each pathway, providing an estimate of the concentration of a chemical at an exposure point, the chemical intake by a receptor must be quantified. Quantifying the frequency, magnitude, and duration of exposures that result from the transport of a chemical to an exposure point is critical to the overall assessment. For this step, the risk assessor calculates the chemical-specific exposures for each exposure pathway identified. Exposure estimates are expressed in terms of the mass of a substance in contact with the body per unit body weight per unit time (e.g., milligrams of a chemical per kilogram body weight per day, also expressed as mg/kg-day).

The exposure quantification process involves gathering information in two main areas: the activity patterns and the biological

Key Chemical Processes

Sorption: the partitioning of a chemical between the liquid and solid phase determined by its affinity for adhering to other solids in the system such as soils and sediment. The amount of chemical that "sorbs" to solids and does not move through the environment is dependent upon the characteristics of the chemical, the characteristics of the surrounding soils and sediments, and the quantity of the chemical. A sorption coefficient is the measure of a chemical's ability to sorb. If too much of the chemical is present, the available binding sites on soils and sediments will be filled and sorption will not continue.

Dissolution/precipitation: the taking in or coming out of solution by a substance. In dissolution a chemical is taken into solution; precipitation is the formation of an insoluble solid. These processes are a function of the nature of the chemical and its surrounding environment and are dependent on properties such as temperature and pH. A chemical's solubility is characterized by a solubility product. Chemicals that tend to volatilize rapidly are not highly soluble.

Degradation: the break down of a chemical into other substances in the environment. Some degradation processes include biodegradation, hydrolysis, and photolysis. Not all degradation products have the same risk as the "parent" compound. Although most degradation products present less risk than the parent compound, some chemicals can break down into "daughter" products that are more harmful than the parent compound. In performing a risk assessment it is important to consider what the daughter products of degradation might be.

Bioaccumulation: the take up/ingestion and storage of a substance into an organism. For substances that bioaccumulate, the concentrations of the substance in the organism can exceed the concentrations in the environment since the organism will store the substance and not excrete it.

Volatilization: the partitioning of a compound into a gaseous state. The volatility of a compound is dependent on its water solubility and vapor pressure. The extent to which a chemical can partition into air is described by one of two constants: Henry's Law or Rauolt's Law. Other factors that are important to volatility are atmospheric temperature and waste mixing.

characteristics (e.g., body weight, inhalation rate) of receptors. Activity patterns and biological characteristics dictate the amount of a constituent that a receptor can intake and the dose that is received per kilogram of body weight. Chemical intake values are calculated using equations that include variables for exposure concentration, contact rate, exposure frequency, exposure duration, body weight, and exposure averaging time. The values of some of these variables depend on the site conditions and the characteristics of the potentially exposed population. For example, the rate of oral ingestion of contaminated food is different for different subgroups of receptors, which might include adults, children, area visitors, subsistence farmers, and subsistence fishers. Children typically drink greater quantities of milk each day than adults per unit body weight. A subsistence fisher would be at a greater risk than another area resident from the ingestion of contaminated fish. Additionally, a child might have a greater rate of soil ingestion than an adult due to playing outdoors or hand-to-mouth behavior patterns. The activities of individuals also determine the duration of exposure. A resident might live in the area for 20 years and be in the area for more than 350 days each year. Conversely, a visitor or a worker will have shorter exposure times. After the intake values have been estimated, they should be organized by population as appropriate (e.g., children, adult residents) so that the results in the risk characterization can be reported for each population group. To the extent feasible, site-specific values should be used for estimating the exposures; otherwise, default values suggested by the EPA in *The Exposure Factors Handbook* (EPA, 1995) can be used.

3. *Risk Characterization*

In the risk-characterization process, the health benchmark information (i.e., cancer slope factors, reference doses, reference concentrations) and the results of the exposure assessment (estimated intake or dose by potentially exposed populations) are integrated to arrive at quantitative estimates of cancer and noncancer risks. To characterize the potential noncarcinogenic effects, comparisons are made between projected intake levels of substances and reference dose or reference concentration values. To characterize potential carcinogenic effects, probabilities that an individual will develop cancer over a lifetime are estimated from projected intake levels and the chemical-specific cancer slope factor value. This procedure is the final calculation step. This step determines who is likely to be affected and what the likely effects are. Because of all the assumptions inherent in calculating a risk, a risk characterization cannot be considered complete unless the numerical expressions of risk are accompanied by explanatory text interpreting and qualifying the results. As shown in the text box, the risk characterization step is different for carcinogens and noncarcinogens.

Calculating Risk

Cancer Risks:

Incremental risk of cancer = average daily dose (mg/kg-day) * slope factor (mg/kg-day)

Non-Cancer Risks:

Hazard quotient = exposure or intake (mg/kg-day) or (mg/m^3)/ RfD (mg/kg-day) or RfC (mg/m^3)

Another consideration during the risk-characterization phase is the cumulative effects of multiple exposures. A given population can be exposed to multiple chemicals from several exposure routes and sources. Multiple constituents might be managed in a single waste management unit, for example, and by considering one chemical at a time, the risks associated with the waste management unit might be underestimated. The EPA has developed guidance outlined in the *Risk Assessment Guidance for Superfund, Volume I* (U.S. EPA, 1989b) to assess the overall potential for cancer and noncancer effects posed by multiple chemicals. The risk assessor, facility manager, and other interested parties should determine the appropriateness of adding the risk contribution of each chemical for each pathway to calculate a cumulative cancer risk or noncancer risk. The procedures for adding risks differ for carcinogenic and noncarcinogenic effects.

The cancer-risk equation described in the adjacent box estimates the incremental individual lifetime cancer risk for simultaneous exposure to several carcinogens and is based on EPA (1989a) guidance. The equation combines risks by summing the risks to a receptor from each of the carcinogenic chemicals.

Cancer Risk Equation for Multiple Substances

$Risk_T = \Sigma Risk_i$

where:

$Risk_T$ = the total cancer risk, expressed as a unitless probability.

$\Sigma Risk_i$ = the sum of the risk estimates for all of the chemical risks.

Assessing cumulative effects from noncarcinogens is more difficult and contains a greater amount of uncertainty than an assessment for carcinogens. As discussed earlier, noncarcinogenic risk covers a diverse set of health effects and different chemicals will have different effects. To assess the overall potential for noncarcinogenic effects posed by more than one chemical, EPA developed a hazard index (HI) approach. The approach assumes that the magnitude of an adverse health effect is proportional to the sum of the hazard quotients of each of the chemicals investigated. In keeping with EPA's *Risk Assessment Guidance*, hazard quotients should only be added for chemicals that have the same critical effect (e.g., both chemicals affect the liver or both initiate respiratory distress). As a result, an extensive knowledge of toxicology is needed to sum the hazard quotients to produce a hazard index. Segregation of hazard indices by effect and mechanism of action can be complex, time-consuming, and will have some degree of uncertainty associated with it. This analysis is not simple and should be performed by a toxicologist.

4. Tiers for Assessing Risk

As part of the Guide, EPA has used a 3-tiered approach for assessing risk associated with air and water releases from waste management units. Under this approach, an acceptable level of protection is provided across all tiers, but with each progressive tier the level of uncertainty in the risk analysis is reduced. Reducing the level of uncertainty in the risk analysis might reduce the level of control required by a waste management unit (if appropriate for the site), while maintaining an acceptable level of protection. The facility performing the risk assessment accepts the higher costs associated with a more complex risk assessment in return for greater certainty and potentially reduced construction and operating costs.

The advantages and relative costs of each tier are outlined below.

Tier 1 Evaluation

- Allows for a rapid but conservative assessment.
- Lower cost.
- Requires minimal site data.
- Contaminant fate-and-transport and exposure assumptions are developed using conservative, non-site specific assumptions provided by EPA. The values are provided in "look-up tables" that serve as a quick and straightforward means for assessing risk. These values are calculated to be protective over a broad range of conditions and situations and are by design very conservative.

Tier 2 Evaluation

- Represents a higher level of complexity.
- Moderate cost.
- Provides the ability to input some site-specific data into the risk assessment and thus provides a more accurate representation of site risk.
- Uses relatively simplistic fate and transport models.

Tier 3 Evaluation

- Provides a sophisticated risk assessment.
- Higher cost.
- Provides the maximum use of site-specific data and thus provides the most accurate representation of site risk.
- Uses more complex fate-and-transport models and analyses.

D. Results

The results of a risk assessment provide a basis for making decisions but are only one element of input into the process of designing a waste management unit. The risk assessment does not constitute the only basis for management action. Other factors are also important, such as technical feasibility of options, public values, and economics. Understanding and interpreting the results for the purpose of making decisions also requires a thorough knowledge of the assumptions that were applied during the risk assessment. Ample documentation should be assembled to describe the scenarios that were evaluated for the risk assessment and any uncertainty associated with the estimate. Information that should be considered for inclusion in the risk assessment documentation include: a description of the contaminants that were evaluated; a description of the risks that are present (i.e., cancer, non-cancer); the level of confidence in the information used in the assessment; the major factors driving the site risks; and the characteristics of the exposed population. The results of a risk assessment are essentially meaningless without the information on how they were generated.

II. Information on Environmental Releases

There are several available sources of information that citizens can review to understand chemical risk better and to review potential environmental release from waste management units in their communities. The Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986 provides one such resource. EPCRA created the Toxic Release Inventory (TRI) reporting program which requires facilities in designated Standard Industry Codes (see 40 CFR §372.22) with more than 10 employees that manufacture or process more than 25,000 pounds, or otherwise use more than 10,000 pounds, of a TRI- listed chemical to report their environmental releases annually to EPA and state governments. Environmental releases include the disposal of wastes in landfills, surface impoundments, land application units, and waste piles. EPA compiles these data in the TRI database and release this information to the public annually. Facility operators might wish to include TRI data in the facility's information repository. TRI data, however, are merely raw data. When estimating risk, other considerations need to be examined and understood too, such as the nature and characteristics of the specific facility and surrounding community.

In 1999, EPA promulgated a final rule that established alternate thresholds for several persistent, bioaccumulative, and toxic (PBT) chemicals (see 64 FR 58665; October 29, 1999). In this rule, EPA has added seven chemicals to the EPCRA Section 313 list of TRI chemicals and lowered the reporting thresholds for another 18 PBT chemicals and chemical categories. For these 18 chemicals, the alternate thresholds are significantly lower than the standard reporting thresholds of 25,000 pounds manufactured or processed, and 10,000 pounds otherwise used.

EPCRA is based on the belief that citizens have a right to know about potential environmental risks caused by facility operations in their communities, including those posed as a result of waste management. TRI data, therefore, provide yet another way for residents to learn about the waste management activities taking place in their neighborhood and to take a more active role in decisions that potentially affect their health and environment. More information on TRI and access to TRI data can be obtained from EPA's Web site **<www.epa.gov/tri>**.

III. Building Partnerships

Building partnerships between all stakeholders—the community, the facility, and the regulators—can provide benefits to all parties, such as:

- Better understanding of waste management activities at an industrial facility.
- Better understanding of facility, state, and community issues.
- Greater support of industry procedures and state policies.
- Reduced delays and costs associated with opposition and litigation.
- A positive image for a company and relationship with the state and community.

Regardless of the size or type of a facility's waste management unit, facilities, states, and local communities can all follow similar principles in the process of building partnerships. These principles are described in various state public involvement guidance documents, various EPA publications, and state requirements for waste facilities. These principles embody sound business practices and common sense and can go beyond state requirements that call for public participation during the issuance of a permit. The Guide recommends principles that can be adopted throughout the operating life of a facility, not just during the permitting process. Following these principles will help all involved consider the full range of activities possible to give partners an active voice in the decision-making process, and in so doing, will result in a positive working relationship.

A. Develop a Partnership Plan

The key to effective involvement is good planning. Developing a plan for how and when to involve all parties in making decisions will help make partnership activities run smoothly and achieve the best results. Developing a partnership plan also helps identify concerns and determine which involvement activities best address those concerns.

The first step in developing a partnership plan is to work with the state agency to understand what involvement requirements exist. Existing state requirements dealing with partnership plans must be followed. (Internet sites for all state environmental agencies are available from **<www.astswmo.org/links.htm>**.) After this step, you should assess the level of community interest generated by a facility's waste management activities. Several criteria influence the amount of public interest, including implications for public health and welfare, current relationships between the facility and community members, and the community's political and economic climate. Even if a facility has not generated much public interest in the past, involving the public is a good idea. Interest in a facility can increase suddenly when changes to existing activities are proposed or when residents' attitudes and a community's political or economic climate change.

To gauge public interest in a facility's waste management activities and to identify the community's major concerns, facility representatives should conduct interviews with community members. They can first talk with members of community groups, such as civic leagues, religious organizations, and business associations. If interest in the facility's waste management activities seems high, facility representatives can consider conducting a more comprehensive set of community interviews. Other individuals to interview include the facility's immediate neighbors, representatives from other agencies and environmental organizations, and any individuals in the community who have expressed interest in the facility's operations.

Using the information gathered during the interviews, facility representatives can develop a list of the community's concerns regarding the facility's waste management activities. They can then begin to engage the community in discussions about how to address those concerns. These discussions can form the basis of a partnership plan.

B. Inform the State and Public About New Facilities or Significant Changes in Facility Operating Plans

A facility's decision to change its operations provides a valuable opportunity for involvement. Notifying the state and public of new units and proposed changes at existing facilities gives these groups the opportunity to identify applicable state requirements and comment on matters that apply to them.

What are examples of effective methods for notifying the public?

Table 1 presents examples of effective methods for public notification and associated advantages and disadvantages. The method used at a particular facility, and within a particular community, will depend on the type of information or issues that need to be communicated and addressed. Public notices usually provide the name and address of the facility representative and a brief description of the change being considered. After a public notice is issued, a facility can develop informative fact sheets to explain proposed changes in more detail. Fact sheets and public notices can include the name and telephone number of a contact person who is available within the facility to answer questions.

What is involved in preparing a meeting with industry, community, and state representatives?

Meetings can be an effective means of giving and receiving comments and addressing concerns. To publicize a meeting, the date, time, and location of the meeting should be placed in a local newspaper and/or advertised on the radio. To help ensure a successful dialogue, meetings should be at times convenient for members of the community, such as early in the evenings during the week, or on weekends. An interpreter might need to be obtained if the local community includes residents whose primary language is not English.

Prior to a meeting, the facility representative should develop a waste management plan or come to the meeting prepared to describe how the industrial waste from the facility will be managed. A waste management plan provides a starting point for public comment and input. Keep data presentations simple and provide information relevant to the audience. Public speakers should be able to respond to both general and technical questions. Also, the facility representative should review and be familiar with the concerns of groups or citizens who have previously expressed an interest in the facility's operations. In addition, it is important to anticipate questions and plan how best to respond to these questions at a meeting.

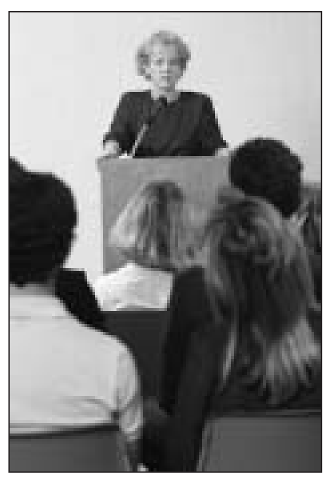

Table 1
Effective Methods for Public Notification

Methods	Features	Advantages	Disadvantages
Briefings	Personal visit or phone call to key officials or group leaders to announce a decision, provide background information, or answer questions.	Provides background information. Determines reactions before an issue "goes public." Alerts key people to issues that might affect them.	Requires time.
Mailing of key technical reports or environmental documents	Mailing technical studies or environmental reports to other agencies, leaders of organized groups, or other interested parties.	Provides full and detailed information to people who are most interested. Often increases the credibility of studies because they are fully visible.	Costs money to print and mail. Some people might not read the reports.
News conferences	Brief presentation to reporters, followed by a question-and-answer period, often accompanied by handouts of presenter's comments.	Stimulates media interest in a story. Direct quotations often appear in television and radio. Might draw attention to an announcement or generate interest in public meetings.	Reporters will only come if the announcement or presentation is newsworthy. Cannot control how the story is presented, although some direct quotations are likely.
Newsletters	Brief description of what is going on, usually issued at key intervals for all people who have shown interest.	Provides more information than can be presented through the media to those who are most interested. Often used to provide information prior to public meetings or key decision points. Helps to maintain visibility during extended technical studies.	Requires staff time. Costs money to prepare, print, and mail. Stories must be objective and credible, or people will react to the newsletters as if they were propaganda.
Newspaper inserts	Much like a newsletter, but distributed as an insert in a newspaper.	Reaches the entire community with important information. Is one of the few mechanisms for reaching everyone in the community through which you can tell the story your way.	Requires staff time to prepare the insert, and distribution costs money. Must be prepared to newspaper's layout specifications.
Paid advertisements	Advertising space purchased in newspapers or on the radio or television.	Effective for announcing meetings or key decisions or as background material for future media stories.	Advertising space can be costly. Radio and television can entail expensive production costs to prepare the ad.
News releases	A short announcement or news story issued to the media to get interest in media coverage of the story.	Might stimulate interest from the media. Useful for announcing meetings or major decisions or as background material for future media stories.	Might be ignored or not read. Cannot control how the information is used.
Presentations to civic and technical groups	Deliver presentations, enhanced with slides or overheads, to key community groups.	Stimulates communication with key community groups. Can also provide in-depth responses.	Few disadvantages, except some groups can be hostile.
Press kits	A packet of information distributed to reporters.	Stimulates media interest in the story. Provides background information that reporters can use for future stories.	Few disadvantages, except cannot control how the information is used and might not be read.
Advisory groups and task forces	A group of representatives of key interested parties is established. Possibly a policy, technical, or citizen advisory group.	Promotes communication between key constituencies. Anticipates public reaction to publications or decisions. Provides a forum for reaching consensus.	Potential for controversy exists if "advisory" recommendations are not followed. Requires substantial commitment of staff time to provide support to committees.

Table 1
Effective Methods for Public Notification (cont.)

Methods	Features	Advantages	Disadvantages
Focus groups	Small discussion groups established to give "typical" reactions of the public. Conducted by a professional facilitator. Several sessions can be conducted with different groups.	Provides in-depth reaction to ideas or decisions. Good for predicting emotional reactions	Gets reactions, but no knowledge of how many people share those reactions. Might be perceived as an effort to manipulate the public.
Telephone line	Widely advertised phone number that handles questions or provides centralized source of information.	Gives people a sense that they know whom to call. Provides a one-step service of information. Can handle two-way communication.	Is only as effective as the person answering the telephone. Can be expensive.
Meetings	Less formal meetings for people to present positions, ask questions, and so forth.	Highly legitimate forum for the public to be heard on issues. Can be structured to permit small group interaction— anyone can speak.	Unless a small-group discussion format is used, it permits only limited dialogue. Can get exaggerated positions or grandstanding. Requires staff time to prepare for meetings.

U.S. EPA 1990. *Sites for Our Solid Waste: A Guidebook for Effective Public Involvement.*

State representatives also should anticipate and be prepared to answer questions raised during the meeting. State representatives should be prepared to answer questions on specific regulatory or compliance issues, as well as to address how the facility has been working in cooperation with the state agency. The following are some questions that are often asked at meetings.

- What are the risks to me associated with the operations?
- Who should I contact at the facility if I have a question or concern?
- How will having the facility nearby benefit the area?
- Will there be any noticeable day-to-day effects on the community?
- Which processes generate industrial waste, and what types of waste are generated?
- How will the waste streams be treated or managed?
- What are the construction plans for any proposed containment facilities?
- What are the intended methods for monitoring and detecting emissions or potential releases?
- What are the plans to address accidental releases of chemicals or wastes at the site?
- What are the plans for financial assurance, closure, and post-closure care?
- What are the applicable state regulations?
- How long will it take to issue the permit?
- How will the permit be issued?
- Who should I contact at the state agency if I have questions or concerns about the facility?

At the meeting, the facility representative should invite public and state comments on the proposed change(s), and tell community members where, and to whom, they should send written comments. A facility can choose to respond to comments in several ways. For example, telephone calls, additional fact sheets, or additional meetings can all be used to address comments. Responding promptly to residents' comments and concerns demonstrates an honest attempt to address them.

C. Make Knowledgeable and Responsible People Available for Sharing Information

Having a facility representative available to answer the public's questions and provide information helps assure citizens that the facility is actively listening to their concerns. Having a state contact available to address the public's concerns about the facility can also make sure that concerns are being heard and addressed.

In addition to identifying a contact person, facilities and states should consider setting up a telephone line staffed by employees for citizens to call and obtain information promptly about the facility. Opportunities for face-to-face interaction between community members and facility representatives include onsite information offices, open houses, workshops, or briefings. Information offices function similarly to information repositories, except that an employee is present to answer questions. Open houses are informal meetings on site where residents can talk to company officials one-to-one. Similarly, workshops and briefings enable community members, state officials, and facility representatives to interact, ask questions, and learn about the activities at the facility. Web sites can also serve as a useful tool for facility, state, and community representatives to share information and ask questions.

D. Provide Information About Facility Operations

Providing information about facility operations is an invaluable way to help the public understand waste management activities. Methods of informing communities include conducting facility tours; maintaining a publicly accessible information repository on site or at a convenient offsite public building such as a library; developing exhibits to explain operations; and distributing information through the publications of established organizations. Examples of public involvement activities are presented in the following pages.

Conduct facility tours. Scheduled facility tours allow community members and state representatives to visit the facility and ask questions about how it operates. By seeing a facility first-hand, residents learn how waste is managed and can become more confident that it is being managed safely. Individual citizens, local officials, interest groups, students, and the media might want to take advantage of facility tours. In planning tours, determine the maximum number of people that can be taken through the facility safely and think of ways to involve tour participants in what they are seeing, such as providing hands-on demonstrations. It is also a good idea to have facility representatives available to answer technical questions in an easy-to-understand manner.

Maintain a publicly accessible information repository. An information repository is simply a collection of documents describing the facility and its activities. It can include background information on the facility, the partnership plan (if developed), permits to manage waste on site, fact sheets, and copies of relevant guidance and regulations. The repository should be in a convenient, publicly accessible place. Repositories are often maintained on site in a public "reading room" or off site at a public library, town hall, or public health office. Facilities should publicize the existence, location, and hours of the repository and update the information regularly.

Develop exhibits that explain facility operations. Exhibits are visual displays, such as maps, charts, diagrams, or photographs, accompanied by brief text. They can provide technical information in an easily understandable way and an opportunity to illustrate creatively and informatively issues of concern. When developing exhibits, identify the target audience, clarify which issue or aspect of the facility's operations will be the exhibit's focus, and determine where the exhibit will be displayed. Public libraries, convention halls, community events, and shopping centers are all good, highly visible locations for an exhibit.

Use publications and mailing lists of established local organizations. Existing groups and publications often provide access to established communication networks. Take advantage of these networks to minimize the time and expense required to develop mailing lists and organize meetings. Civic or environmental groups, rotary clubs, religious organizations, and local trade associations might have regular meetings, newsletters, newspapers, magazines, or mailing lists that could be useful in reaching interested members of the community.

American Chemistry Council's Responsible Care®

To address citizens' concerns about the manufacture, transport, use, and disposal of chemical products, the American Chemistry Council (ACC) launched its Responsible Care® program in 1988. To maintain their membership in ACC, companies must participate in the Responsible Care® program. One of the key components of the program is recognizing and responding to community concerns about chemicals and facility operations.

ACC member are committed to fostering an open dialogue with residents of the communities in which they are located. To do this, member companies are required to address community concerns in two ways: (1) by developing and maintaining community outreach programs, and (2) by assuring that each facility has an emergency response program in place. For example, member companies provide information about their waste minimization and emissions reduction activities, as well as provide convenient ways for citizens to become familiar with the facility, such as tours. Many companies also set up Community Advisory Panels. These panels provide a mechanism for dialogue on issues between plants and local communities. Companies must also develop written emergency response plans that include information about how to communicate with members of the public and consider their needs after an emergency.

Responsible Care® is just one example of how public involvement principles can be incorporated into everyday business practices. The program also shows how involving the public makes good business sense. For more information about Responsible Care®, contact ACC at 703 741-5000.

AF&PA's Sustainable Forestry Initiative

Public concern about the future of America's forests coupled with the American Forest & Paper Association's (AF&PA's) belief that "sound environmental policy and sound business practice go hand in hand" fueled the establishment of the Sustainable Forestry Initiative (SFI). Established in 1995, the SFI outlines principles and objectives for environmental stewardship with which all AF&PA members must comply in order to retain membership. SFI encourages protecting wildlife habitat and water quality, reforesting harvested land, and conserving ecologically sensitive forest land. SFI recognizes that continuous public involvement is crucial to its ultimate goal of "ensuring that future generations of Americans will have the same abundant forests that we enjoy today."

The SFI stresses the importance of reaching out to the public through toll-free information lines, environmental education, private and public sector technical assistance programs, workshops, videos, and other means. To help keep the public informed of achievements in sustainable forestry, members report annually on their progress, and AF&PA distributes the resulting publication to interested parties. In addition, AF&PA runs two national forums a year, which bring together loggers, landowners, and senior industry representatives to review progress toward SFI objectives.

Many AF&PA state chapters have developed additional activities to inform the public about the SFI. For example, in New Hampshire, AF&PA published a brochure about sustainable forestry and used it to brief local sawmill officials and the media. In Vermont, a 2-hour interactive television session allowed representatives from industry, public agencies, environmental organizations, the academic community, and private citizens to share their views on sustainable forestry. Furthermore, in West Virginia, AF&PA formed a Woodland Owner Education Committee to reach out to nonindustrial private landowners.

For more information about the SFI, contact AF&PA at 800 878-8878, or visit the Web site **<www.afandpa.org>**.

Understanding Risk and Building Partnerships Activity List

You should consider the following activities in understanding risk and building partnerships between facilities, states, and community members when addressing potential waste management practices.

- ❑ Understand the definition of risk.
- ❑ Review sources for obtaining health benchmarks.
- ❑ Understand the risk assessment process including the pathways and routes of potential exposure and how to quantify or estimate exposure.
- ❑ Be familiar with the risk assessment process for cancer risks and non-cancer risks.
- ❑ Develop exhibits that provide a better understanding of facility operations.
- ❑ Identify potentially interested/affected people.
- ❑ Notify the state and public about new facilities or significant changes in facility operating plans.
- ❑ Set up a public meeting for input from the community.
- ❑ Provide interpreters for public meetings.
- ❑ Make knowledgeable and responsible people available for sharing information.
- ❑ Develop a partnership plan based on information gathered in previous steps.
- ❑ Provide tours of the facility and information about its operations.
- ❑ Maintain a publicly accessible information repository or onsite reading room.
- ❑ Develop environmental risk communication skills.

Resources

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Appendix

ATSDR

CADMIUM
CAS # 7440-43-9

Agency for Toxic Substances and Disease Registry ToxFAQs **June 1999**

This fact sheet answers the most frequently asked health questions (FAQs) about cadmium. For more information, call the ATSDR Information Center at 1-888-422-8737. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It's important you understand this information because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Exposure to cadmium happens mostly in the workplace where cadmium products are made. The general population is exposed from breathing cigarette smoke or eating cadmium contaminated foods. Cadmium damages the lungs, can cause kidney disease, and may irritate the digestive tract. This substance has been found in at least 776 of the 1,467 National Priorities List sites identified by the Environmental Protection Agency (EPA).

What is cadmium?

(Pronounced kăd′mē-əm)

Cadmium is a natural element in the earth's crust. It is usually found as a mineral combined with other elements such as oxygen (cadmium oxide), chlorine (cadmium chloride), or sulfur (cadmium sulfate, cadmium sulfide).

All soils and rocks, including coal and mineral fertilizers, contain some cadmium. Most cadmium used in the United States is extracted during the production of other metals like zinc, lead, and copper. Cadmium does not corrode easily and has many uses, including batteries, pigments, metal coatings, and plastics.

What happens to cadmium when it enters the environment?

- Cadmium enters air from mining, industry, and burning coal and household wastes.
- Cadmium particles in air can travel long distances before falling to the ground or water.
- It enters water and soil from waste disposal and spills or leaks at hazardous waste sites.
- It binds strongly to soil particles.
- Some cadmium dissolves in water.
- It doesn't break down in the environment, but can change forms.
- Fish, plants, and animals take up cadmium from the environment.
- Cadmium stays in the body a very long time and can build up from many years of exposure to low levels.

How might I be exposed to cadmium?

- Breathing contaminated workplace air (battery manufacturing, metal soldering or welding).
- Eating foods containing it; low levels in all foods (highest in shellfish, liver, and kidney meats).
- Breathing cadmium in cigarette smoke (doubles the average daily intake).
- Drinking contaminated water.
- Breathing contaminated air near the burning of fossil fuels or municipal waste.

How can cadmium affect my health?

Breathing high levels of cadmium severely damages the lungs and can cause death. Eating food or drinking water with very high levels severely irritates the stomach, leading to vomiting and diarrhea. Long-term exposure to lower levels of cadmium in air, food, or water leads to a buildup of cadmium in the kidneys and possible kidney disease.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES, Public Health Service
Agency for Toxic Substances and Disease Registry

Page 2

CADMIUM
CAS # 7740-43-9

ToxFAQs Internet address via WWW is http://www.atsdr.cdc.gov/toxfaq.html

Other long-term effects are lung damage and fragile bones. Animals given cadmium in food or water had high blood pressure, iron-poor blood, liver disease, and nerve or brain damage.

We don't know if humans get any of these diseases from eating or drinking cadmium. Skin contact with cadmium is not known to cause health effects in humans or animals.

How likely is cadmium to cause cancer?

The Department of Health and Human Services (DHHS) has determined that cadmium and cadmium compounds may reasonably be anticipated to be carcinogens.

How can cadmium affect children?

The health effects in children are expected to be similar to those in adults (kidney, lung and intestinal damage).

We don't know if cadmium causes birth defects in people. Cadmium does not readily go from a pregnant woman's body into the developing child, but some portion can cross the placenta. It can also be found in breast milk. The babies of animals exposed to high levels of cadmium during pregnancy had changes in behavior and learning ability. Cadmium may also affect birth weight and the skeleton in developing animals.

Animal studies also indicate that more cadmium is absorbed into the body if the diet is low in calcium, protein, or iron, or is high in fat. A few studies show that younger animals absorb more cadmium and are more likely to lose bone and bone strength than adults.

How can families reduce the risk of exposure to cadmium?

In the home, store substances that contain cadmium safely, and keep nickel-cadmium batteries out of reach of young children. If you work with cadmium, use all safety precautions to avoid carrying cadmium-containing dust home from work on your clothing, skin, hair, or tools.

A balanced diet can reduce the amount of cadmium taken into the body from food and drink.

Is there a medical test to show whether I've been exposed to cadmium?

Tests are available in some medical laboratories that measure cadmium in blood, urine, hair, or nails. Blood levels show recent exposure to cadmium, and urine levels show both recent and earlier exposure. The reliability of tests for cadmium levels in hair or nails is unknown.

Has the federal government made recommendations to protect human health?

The EPA has set a limit of 5 parts of cadmium per billion parts of drinking water (5 ppb). EPA doesn't allow cadmium in pesticides.

The Food and Drug Administration (FDA) limits the amount of cadmium in food colors to 15 parts per million (15 ppm).

The Occupational Safety and Health Administration (OSHA) limits workplace air to 100 micrograms cadmium per cubic meter (100 µg/m^3) as cadmium fumes and 200 µg cadmium/m^3 as cadmium dust.

Source of Information

Agency for Toxic Substances and Disease Registry (ATSDR). 1999. Toxicological profile for cadmium. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Where can I get more information? For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology, 1600 Clifton Road NE, Mailstop E-29, Atlanta, GA 30333. Phone: 1-888-422-8737, FAX: 404-639-6359. ToxFAQs Internet address via WWW is http://www.atsdr.cdc.gov/toxfaq.html ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.